Evaluating cotton irrigation efficiency

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Australian agriculture uses 70 per cent of the total water consumed each year. Irrigators are faced with increased competition from urban, industrial and environmental consumers demanding a larger share of this limited resource on one of the driest continents in the world. So all water users must strive to adopt more efficient irrigation techniques to ensure their long-term sustainability.

The Queensland Government Rural Water Use Efficiency Initiative (RWUEI), Cotton and Grains Adoption Program being conducted by Queensland DPI through the Australian Cotton CRC, has worked in partnership with the major irrigation industries in the state over the past two years. The initiative has operated in the five major cotton valleys from Emerald to St George to identify better management practices for existing irrigation systems (see story on page 38).

The cotton industry relies mainly on furrow irrigation (96 per cent) with the balance pressurised overhead systems — such as centre pivots — and subsurface drip.

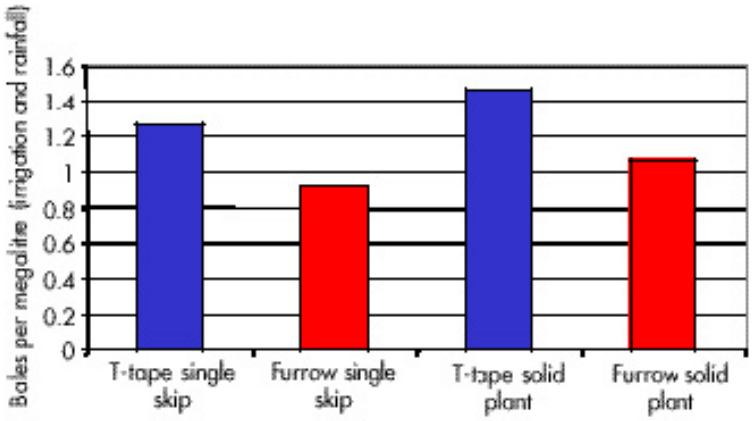
Although dam evaporation can be the single biggest loss — up to 50 per cent of total water stored in some cases — currently there are no cost effective measures to reduce these losses. The RWUEI followed the recommendation from Paul Dalton's work in the Border Rivers region, which identified that the most cost-effective changes to improve efficiency could be made at the field level.

Irrigation evaluation

Irrigators must be aware that when we talk about improving water use efficiency, considerable gains can result from accurate monitoring, evaluating and fine-tuning of existing systems.

Furrow irrigation efficiencies can be improved when closer attention is paid to optimising the system and these are often not hard to achieve. Individual application efficiencies were measured in trials on the Darling Downs and ranged from

FIGURE 1: Water use efficiency trials comparing cotton irrigated with drip or furrow under single skip or solid plant configuration



Monitoring is the key to achieving improvements in irrigation efficiencies.

30 to 95 per cent.

To achieve efficiency gains we need to monitor the existing system — we must “measure to manage”. This can be as simple as benchmarking our current practices to know where we are and to identify where we can improve.

Reasons for poor irrigation efficiencies include:

• Poorly designed systems (for example a system’s supplies not matching crop demand);

• Serious system limitations (for example insufficient head for optimum siphon flow rates);

• Not understanding the complete farm water balance and poor matching of soil deficits with application rates;

• Production losses due to over-watering (waterlogging); and,

• Lack of crop agronomic understanding to fully maximise water use efficiency gains.

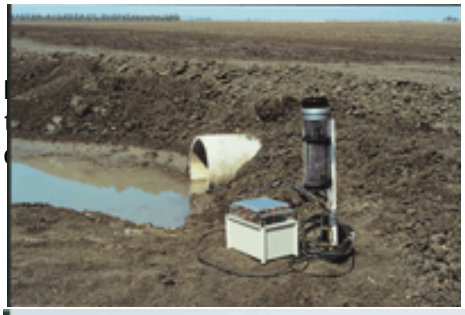
It is a little more difficult to relate volumetric gains to improvement in yield per megalitre of total water used. To achieve this it is crucial that the crop’s agronomic characteristics are fully understood and the correct practices are followed — for example, by monitoring crop stages such as internode length, nodes above last white flower, fruiting loads and varietal differences.

Scheduling

There have been many debates about scheduling tools, their accuracy and calibration. The neutron probe has been the industry standard, but its accuracy, unless properly calibrated to specific soils, is no better than other newer, easier to use tools on the market.

Continuous capacitance scheduling tools have allowed irrigators to closely observe the interaction of their crop with water and soil. More importantly they have given a real time picture of soil water use in an easy to understand format.

These tools have shown that there are a considerable number of days of very poor or no root activity after an irrigation event, especially in some of the heavier soil types. This can be best seen in poorly managed irrigation systems where the application rates and volumes are not closely matched to the soil deficit. This is usually the result of low siphon inflow rates, very long furrow lengths or an irrigation event allowed to run for too long.



Trials have shown that both yield and water use efficiency can be improved with more controlled irrigation systems.

The RWUEI has promoted the use of scheduling tools, as soil moisture monitoring is crucial to ensure that we have a clear understanding of crop water use and extraction patterns. Monitoring is far more important with drip and overhead systems as in these cases the soil moisture profile must be maintained at a level where it would not inhibit crop yield potential.

It's not until we monitor irrigations, and use other tools such as yield maps, that we realise over-irrigation is not only using more water, but is also costing us money in production losses.

For example:

• Yield loss from waterlogging can be up to two bales per hectare;

• Five to 20 per cent of tailwater can be lost from evaporation and seepage in tailwater recycling systems. On most cotton farms tailwater is fully recycled, but we need to pump it at a minimum cost of one dollar per megalitre per metre head; and,

• Deep drainage losses — the percentage of applied water and nutrients draining below the effective root zone. (It is a contentious point, but irrigation designers should normally allow for some drainage below the root zone — also known as the leaching fraction.)

SIRMOD

At several RWUEI trial sites the following data were collected:

• Soil moisture deficits;

• Application rates;

• Advance rates;

• Furrow slope;

• Furrow cross sectional area; and,

• Furrow length.

With these data and a simulation model called SIRMOD it was possible to calculate the application efficiency, distribution uniformity, infiltration characteristics and rate of infiltration below the target area of the application (the effective root zone). The model effectively demonstrates what happens to a system's irrigation efficiency when flow rate, management or design changes are made.

Alternative systems

In the past many irrigators have thought that to

improve irrigation efficiency they need to change irrigation systems, such as from furrow to drip. System changes have normally meant substantial capital investment and growers have questioned whether this is justified. Although the cotton industry has had several major disasters with these systems, their failure can be directly attributed to poor design, installation and lack of understanding of their management. Results from trials by the RWUEI have indicated that both crop yield and water use efficiency can be improved with more controlled systems, such as overhead irrigation or subsurface drip.

With greater control of application rates irrigations can be fine tuned to more accurately match the daily crop water use. And with a correctly designed system and an understanding of the crop's agronomic stages, more controlled systems will result in better use of in-crop rain and reduced losses from severe waterlogging.

As an example, RWUEI trials have looked at solid and single skip cotton under furrow and drip irrigation. Cotton grown under single skip and irrigated with drip produced half a bale per megalitre (total water applied including rainfall and irrigation) more than a furrow-irrigated crop grown as single skip. Solid-planted, drip-irrigated cotton was 0.45 bales per megalitre better than the same crop type under furrow irrigation (Figure 1).

There is a good potential for increased use of drip irrigation, especially as the value of water increases and more is learnt about how to fine tune management of drip irrigation systems in cotton crops.

One limitation, once a field is set up with subsurface drip, is it is very difficult to justify fallowing the block because of the high investment in the system. A solution to the high cost of drip irrigation may be temporary, low cost drip — a system was trialled on the Downs in single skip and the final cost was close to $1200 per hectare. These cheaper drip systems may be useful in sensitive areas where only ground rigs can be used for insect control or in areas where head ditches impede overland flows.

Centre pivot irrigation in the cotton industry may also become more popular because the cost per hectare is comparable to establishing furrow irrigation. Centre pivots may be more attractive than lateral overhead systems because labour costs to operate them tend to be less. Centre pivots are very popular in the US — in fact, they are the most widely-used irrigation system in the US cropping systems

1: The RWUE Initiative is an Australian Cotton Cooperative Research Centre program.